BOUNDS ON "CHARGINOS NEARLY DEGENERATE WITH THE LIGHTEST NEUTRALINO" MASS FROM PRECISION MEASUREMENTS

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Though LEP II direct searches still cannot exclude a chargino nearly degenerate with the lightest neutralino if its mass is only slightly above half of the Z boson mass and the sneutrino is light, it can be excluded indirectly analyzing precision data. In this particular limit simple analytical formulas for oblique electroweak radiative corrections are presented.

1 Introduction

According to the latest searches performed at LEP II at center-of-mass energies up to 189 GeV, the present bounds on chargino mass are $m_{\tilde{\chi}^\pm} \gtrsim 90$ GeV for the higgsino-dominated case (or when the sneutrino is heavy) and $m_{\tilde{\chi}^\pm} \gtrsim 80$ GeV in the wino-dominated light-sneutrino scenario. [1,2] However, when the lightest chargino and neutralino (the latter being the LSP) are almost degenerate in mass, the charged decay products of the light chargino are very soft, and the above quoted bounds are no longer valid. A special search for such light charginos has been performed recently by the DELPHI collaboration, and the case of $\Delta M^\pm \equiv m_{\tilde{\chi}_1^\pm} - m_{\tilde{\chi}_1^0} \lesssim 100$ MeV is now excluded. [1,2] In the region $\Delta M^\pm \sim 1$ GeV the analysis of the Initial State Radiation (ISR) can be used to put a limit on the chargino mass, [2] but in the case of wino domination with a light sneutrino this technique fails and charginos as light as 45 GeV (this bound coming from the measurements of Z decays at LEP I and SLC) are still allowed. The case of almost degenerate chargino and neutralino can be naturally realized in SUSY and the possibilities to find such particles are discussed in literature. [3]

In this talk we investigate the radiative corrections to the electroweak precision measurements generated by such almost degenerate particles. [4,5] When their masses are close to $m_Z/2$ one-loop contributions are large and they spoil the perfect description of experimental data by the Standard Model. Due to the decoupling property of SUSY models, when $m_{\tilde{\chi}^{\pm,0}} \gg m_Z$ the radiative

corrections are power suppressed.

2 Discussion

The contributions of new physics to the electroweak precision data through oblique corrections can be conveniently parameterized in terms of the three functions V_m, V_A and V_R. [6] In the simplest supersymmetric extensions of the Standard Model the chargino-neutralino sector is defined by the numerical values of the four parameters M_1, M_2, μ and $\tan\beta$, and the case of nearly degenerate lightest chargino and neutralino naturally arise when:

- $M_2 \gg \mu$: in this limit the particles of interest form an $SU(2)$ doublet of Dirac fermions, whose wave functions are dominated by *higgsinos*, and their contribution to the V_i functions is: [4]

$$\delta^{\tilde{h}} V_m = \frac{16}{9}\Bigg[\left(\frac{1}{2} - s^2 + s^4\right)(1+2\chi)\,F(\chi) - \left(\frac{1}{2} - s^2\right)\left(1 + 2\frac{\chi}{c^2}\right) F\left(\frac{\chi}{c^2}\right) - \frac{s^4}{3}\Bigg], \tag{1}$$

$$\delta^{\tilde{h}} V_A = \frac{16}{9}\left(\frac{1}{2} - s^2 + s^4\right)\left[\frac{12\chi^2 F(\chi) - 2\chi - 1}{4\chi - 1}\right], \tag{2}$$

$$\delta^{\tilde{h}} V_R = \frac{16}{9} c^2 s^2 \left[(1+2\chi)\,F(\chi) - \frac{1}{3}\right], \tag{3}$$

  where $\chi \equiv (m_{\tilde{\chi}^{\pm,0}}/m_Z)^2$, the function F is defined in App. B of Ref. [6], and s^2 (c^2) is the sine (cosine) squared of the electroweak mixing angle;

- $\mu \gg M_2$: in this case we get an $SU(2)$ triplet of Majorana fermions, with the wave functions dominated by *winos*, and the expressions for the corrections to V_i are: [4]

$$\delta^{\tilde{w}} V_m = \frac{16}{9}\Bigg[c^4\,(1+2\chi)\,F(\chi) - (1 - 2s^2)\left(1 + 2\frac{\chi}{c^2}\right) F\left(\frac{\chi}{c^2}\right) - \frac{s^4}{3}\Bigg], \tag{4}$$

$$\delta^{\tilde{w}} V_A = \frac{16}{9} c^4 \left[\frac{12\chi^2 F(\chi) - 2\chi - 1}{4\chi - 1}\right], \tag{5}$$

$$\delta^{\tilde{w}} V_R = \frac{16}{9} c^2 s^2 \left[(1+2\chi)\,F(\chi) - \frac{1}{3}\right]. \tag{6}$$

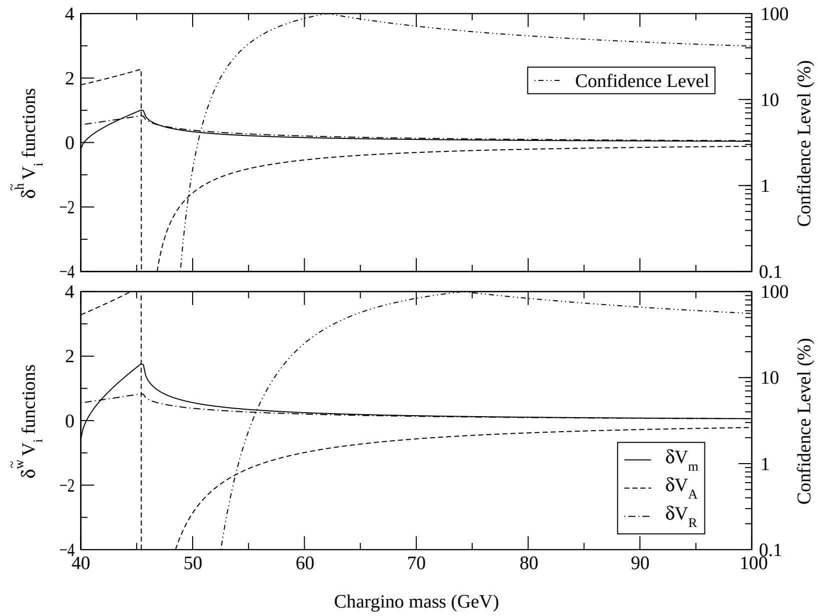

Figure 1. Dependence of the δV_i functions (left Y-axes) and of the Confidence Levels (right Y-axes) on the light chargino-neutralino mass $m_{\tilde{\chi}^{\pm,0}}$, in the limits $M_2 \gg \mu$ (higgsino-dominated case, upper panel) and $\mu \gg M_2$ (wino-dominated case, lower panel).

The χ^2 for the new physics contributions to V_i was computed using the computer program `LEPTOP`, [6,7] and the corresponding Confidence Level (together with the numerical value of the δV_i functions) is plotted in Fig. 1 against the chargino-neutralino mass $m_{\tilde{\chi}^{\pm,0}}$. We see that at 95% C.L. the bounds $m_{\tilde{\chi}^{\pm,0}} \gtrsim 51$ GeV (higgsino-dominated case) and $m_{\tilde{\chi}^{\pm,0}} \gtrsim 56$ GeV (wino-dominated case) should be satisfied. Note that the main contribution to χ^2 comes from δV_A, which is singular at $m_{\tilde{\chi}^{\pm,0}} = m_Z/2$. This singularity is not physical and our formulas are valid only for $2m_{\tilde{\chi}^{\pm,0}} \gtrsim m_Z + \Gamma_Z$; however, the existence of $\chi^{\pm}$ with a mass closer to $m_Z/2$ will change Z-boson Breit-Wigner curve, therefore it is also not allowed. [8]

3 Conclusions

Let us briefly discuss the contributions of other SUSY particles to the V_i functions. In the considered limits the remaining charginos and neutralinos

are very heavy, so they simply decouple. The contributions of the three generations of sleptons (with masses larger than 90 GeV) and of the first two generations of squarks (with masses larger than 200 GeV to satisfy Tevatron bounds) into V_A are smaller than 0.1, so they can safely be neglected. Concerning the contributions of the third generation squarks, although enhanced by the large top-bottom mass difference they are almost universal, [9] so compensating the negative value of V_A will generate large positive terms into V_R and V_m and the overall χ^2 will not be better. Finally, according to Ref. [10] the contribution to radiative corrections of the whole MSSM Higgs sector equals with very good accuracy that of a single SM higgs with the same mass as the lightest MSSM neutral higgs, so it is already accounted for in our analysis.

Let us remark that in the case of wino domination with a light sneutrino, which occurs naturally in anomaly-mediated SUSY breaking scenarios, [3] the analysis of the ISR fails [2] and the bound $m_{\tilde{\chi}^{\pm,0}} \gtrsim 56$ GeV from precision measurements is presently the strongest constraint which can be imposed on the chargino-neutralino mass.

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